CLAIMS

1. A substantially sulfur-free process for the production of a chemical pulp from lignocellulosic material and the recovery of chemicals used in said process comprising the steps of:

a) providing a feed stream of comminuted lignocellulosic material,

b) subjecting said feed stream of comminuted lignocellulosic material to a pretreatment,

c) reacting the pretreated lignocellulosic material from step b) with oxygen or oxygen-containing gas, in the presence of an alkaline buffer solution comprising at least one sodium or potassium compound in order to obtain a stream of at least partially delignified lignocellulosic material,

d) further treating said at least partially delignified material from step c) to obtain a chemical pulp product,

e) extracting spent liquor comprising dissolved lignin components and spent chemical substances from step b) or both steps b) and c),

f) recovery of chemical substances from the spent liquor obtained in step e) and preparation of fresh alkaline buffer solution to be charged to step c) or both steps c) and b),

wherein in step b) said comminuted lignocellulosic material is subjected to a mild prehydrolysis in an aqueous solution and thereafter precooked in the presence of an alkaline buffer solution, and

in step b) an aromatic organic compound is added to promote selective delignification, and

in step f) the recovery of chemical substances from the spent liquor obtained in step e) comprises,

f_1) treating at least part of said spent liquor to form a concentrated stream of cellulose spent liquor,

f_2) reacting said concentrated cellulose spent liquor stream with an oxygen containing gas at elevated temperature in a gas generator to form a hot gas comprising carbon dioxide and molten droplets or an aerosol of sodium or potassium compounds,

f_3) dissolving said sodium or potassium compounds in water to form an alkaline buffer solution and

f_4) recycling and charging at least a portion of said alkaline buffer solution to step c) or both steps c) and b).

2. A process according to claim 1, wherein at least one agent active in enhancing selective delignification is added to the oxygen delignification step c), and wherein at least a part of said agent or its precursor is formed or recovered from step f) and recycled to step c).

3. A process according to claim 1, wherein said mild prehydrolysis in step b) is being effected by the addition of steam to a vessel comprising the lignocellulosic material.

4. A process according to claim 1 and 3, wherein the temperature during said mild prehydrolysis is maintained between 50 - 150°C under a time period of about 5 to 140 minutes, preferably between 50 and 120°C under 20 to 80 min.

5. A process according to claim 4, wherein a filtrate recycled from a bleach plant is added to the mild prehydrolysis stage in step b).

6. A process according to claim 1 wherein precooking of the lignocellulosic material in step b) is performed in a temperature range from about 110°C to about 200°C for a period of about 3 minutes to about 6 hours in order to obtain an at least partly delignified lignocellulosic material.

7. Process according to claim 6, wherein the alkaline buffer solution primarily is made up of alkali metal hydroxides and carbonates, alkali metal borates or phosphates.

8. Process according to claim 2, wherein said agent is a carbohydrate protector, such protector being composed of at least one of magnesium and silicon compounds, hydrazines, boron hydride of alkaline metals and iodine compounds.

9. Process according to claim 1, wherein an aromatic organic compound added to step b) is a delignification catalyst preferably anthraquinone or a derivative of anthraquinone.

10. Process according to claim 1 wherein an aromatic organic compound capable of preventing lignin condensation reactions is added to the mild prehydrolysis stage in step b) such compound preferably comprising 2-naphthol or a xylenol.

11. Process according to claim 1, wherein the comminuted lignocellulosic material is treated in step b) with an active oxygen compound such as chlorine dioxide, ozone, oxygen, hydrogen peroxide or a peroxyacid in order to oxidize at least a portion of the lignin before the material is treated with oxygen in step c).

12. Process according to claim 1, wherein lignocellulosic material is subjected to mechanical defiberization before step c), said mechanical defiberization being effected by an energy input ranging from about 50 to about 500 kWh/ton of dry cellulosic material and more preferably in the range of 50 to 300 kWh/ton.

13. Process according to claim 1, wherein oxygen delignification is performed in the presence of an alkaline buffer largely made up of alkali carbonate or alkali borate and wherein such buffer originates in the chemicals recovery system and is transferred and used in said oxygen delignification without having been subjected to causticizing.

14. Process according to claim 1 and claim 13, wherein oxygen delignification is performed in the presence of at least one chemical reagent, said reagent being

selected from one or more of a carbohydrate protector, a transition metal catalyst with a central atom selected from copper, manganese, iron, cobalt or ruthenium.

15. Process according to claim 14, wherein a transition metal catalyst is coordinated with a ligand comprising nitrogen.

16. Process according to claim 15, wherein said transition metal catalyst is coordinated by ammonia, triethanolamine, phenanthroline, bipyridyl, pyridine, triethylenetetraamine, diethylenetriamine, acetylacetone, ethylenediamine, cyanide and oxyquinolines.

17. Process according to claim 14, wherein a transition metal catalyst is present during oxygen delignification in a concentration ranging from about 10 ppm to about 5000 ppm, preferably from about 10 to 300 ppm calculated on basis of dry lignocellulosic material.

18. Process according to any of the preceding claims, wherein oxygen delignification is performed in the presence of a carbohydrate protector composed of an organic radical scavenger, a magnesium or a iodine compound or combinations thereof.

19. Process according to claim 18, wherein the magnesium compound is selected from magnesium compounds soluble in alkaline solutions.

20. Process according to claim 18, wherein an iodine compound is present in a concentration corresponding to 1 to 15 %, more preferably from 3-8 % calculated on the lignocellulosic material.

21. Process according to claim 18, wherein an organic radical scavenger is an alcohol, amine or a ketone or combinations thereof.

22. Process according to claim 21, wherein amines, alcohols and ketones are selected from amines such as ethanolamines and ethylenediamine and alcohols such as methanol, ethanol, n-propanol, isobutyl alcohol, neopentyl alcohol and resorcinol and ketones such as acetone.

23. Process according to claim 18, wherein the organic radical scavenger is present in a concentration from about 0.1 % to about 10 % on dry cellulosic material, preferably from about 0.5 to 3 %.

24. Process according to any of the preceding claims, wherein a polyelectrolyte or a surface active agent or combinations of polyelectrolytes and surface active agents are added in step c) in order to increase and facilitate mass transfer of oxygen in an oxygen delignification stage.

25. Process according to claim 24, wherein a polyelectrolyte is selected from cross-linked polyelectrolytes including phosphazenes, imino-substituted polyphosphazenes, polyacrylic acids, polymethacrylic acids, polyvinyl acetates, polyvinyl amines, polyvinyl pyridine, polyvinyl imidazole, and ionic salts thereof.

26. Process according to claim 24, wherein a surface active agent is selected from non ionic or zwitterionic compounds including poly(ethyleneoxy)/(propyleneoxy) block copolymers, fatty acids and fatty amines which have been ethoxylated; polyhydroxyl non-ionic (polyols) and a quaternized poly(propylene glycol) carboxylate or lecithin.

27. Process according to claim 24, wherein a high molecular weight polyethyleneglycol is added to an alkaline buffer liquor or to an oxygen delignification stage in a quantity on the order of 0.2 percent or less on the lignocellulosic material in order to reduce the viscosity of the pulping liquor.

28. Process according to any of the preceding claims, wherein an oxygen delignification stage is carried out in consistencies ranging from about 1 to 30 %.

29. Process according to any of the preceding claims wherein a lignocellulosic material treatment using oxygen compounds is carried out in a pressurized diffuser reactor.

30. Process according to claim 1, wherein:

in step b) anthraquinone, 2-naphtol or xylenol or derivatives thereof is added to be present during the pretreatment, and

in step c) said alkaline buffer substantially is made up of an alkali carbonate or an alkali borate or combinations thereof, and

in step f_2) said concentrated spent cellulose liquor from step f_1) is reacted with an oxygen containing gas in a reaction zone of a gas generator at a temperature in the range of 700-1300°C to produce a hot raw gas comprising carbon dioxide and at least one of H_2, CO, H_2O, and NH_3, said raw gas containing entrained molten particulate matter and an aerosol of alkaline compounds, and

at least a major portion of said entrained particulate molten matter being separated from the raw gas stream and dissolved in an aqueous solution to form an alkaline solution comprising sodium or potassium compounds, and

wherein at least a portion of said alkaline solution is recycled to the oxygen delignification step c), without having been subjected to causticizing.

31. Process according to claim 30, wherein said hot raw gas is cooled and cleaned to produce a clean gas stream substantially free from particulate matter and alkali metal compounds.

32. Process according to claim 30, wherein a major portion of the entrained particulate molten matter is separated from the raw gas by gravity in a gas diversion and smelt separation zone arranged in or adjacent to the gas generator, such separation being effected without substantially reducing the temperature of the hot gas stream.

33. Process according to claim 30, wherein a gas generator is an updraft gasifier with smelt removal in a lower section of the gas generator and wherein the hot raw fuel gas is discharged from an upper section of the gas generator.

34. Process according to claim 30, wherein the addition of oxygen containing gas to the gas generator corresponds to 30 - 65 % of stoichiometric complete combustion of the cellulose spent liquor.

35. Process according to claim 30, wherein the pressure in the gas generator ranges from about 0.1 MPa to 10 MPa, more preferably from about 1.8 to about 4.0 MPa.

36. Process according to claim 31, wherein cellulose spent liquor is completely oxidized in the gas generator or reactor and wherein hot raw gas comprising carbon dioxide and steam, after separation of alkaline compounds, cooling and optional removal of trace contaminants and particulates, is discharged to the atmosphere.

37. Process according to any of the preceding claims, wherein an alkaline buffer solution comprising sodium or potassium compounds is subjected to an oxidative treatment with an oxygen containing gas in order to activate chemical reagents, catalysts or carbohydrate protectors and/or to eliminate any traces of sulfide before the alkaline buffer solution is recycled as desired to a pretreatment, precooking or an oxygen delignification stage.

38. Process according to claim 1, wherein:

a portion of the lignin and other organic material in a cellulose spent liquor stream from step b) or c) or a digester circulation stream is extracted and separated from the spent liquor stream or digester circulation stream before it is discharged to concentration or combustion in order to recover substantially sulfur chemicals free lignin and other organic material.

a spent liquor stream recovered after extraction of lignin an other organic material is discharged and withdrawn to be further processed in a recovery system according to steps f_1) to f_4) to recover inorganic chemicals, chemical reagents or chemical reagent precursors and energy values.

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